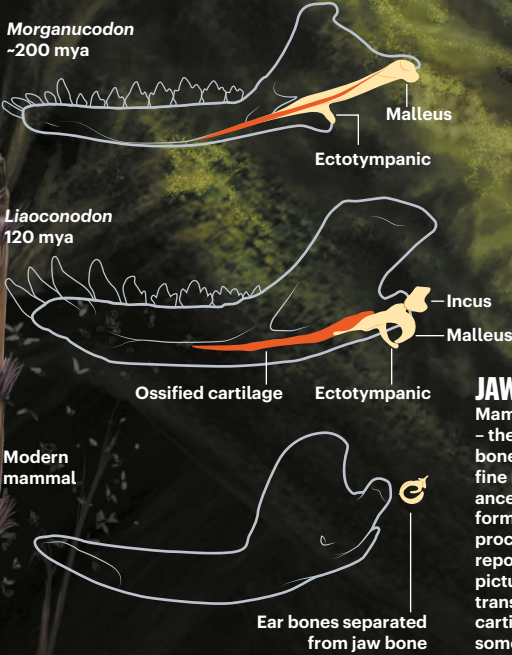


# MAMMAL HALLMARKS

A raft of extraordinary fossil finds is revealing details of how mammals evolved from reptilian forebears more than 178 million years ago. Discoveries in the past two decades show that early mammals were a diverse bunch, with sophisticated skills such as gliding and burrowing that researchers thought evolved only later. Many of the features that define mammals – like suckling milk, exceptional hearing and small litter sizes – had already appeared by the time true mammals were roaming the land, rivers and skies.

By John Pickrell  
Illustration by Davide Bonadonna  
Design by Wes Fernandes



**JAW BECOMES EAR**  
Mammals have three middle ear bones – the malleus, incus and ectotympanic bone (yellow) – responsible for their fine hearing. In reptiles and the ancestors of mammals, these bones formed part of the jaw and helped to process food. When researchers reported *Liaconodon hui* in 2011 (main picture), they realized it represented a transitional state: a piece of hardened cartilage in the jaw (orange) supported some of the bones and the eardrum.

**WALKING WITH DINOSAURS**  
Early mammals like this rat-sized species *Liaconodon hui* coexisted with feathered dinosaurs like *Sinotyrannus* in the temperate ecosystems of the Cretaceous in what is now Liaoning in northern China.

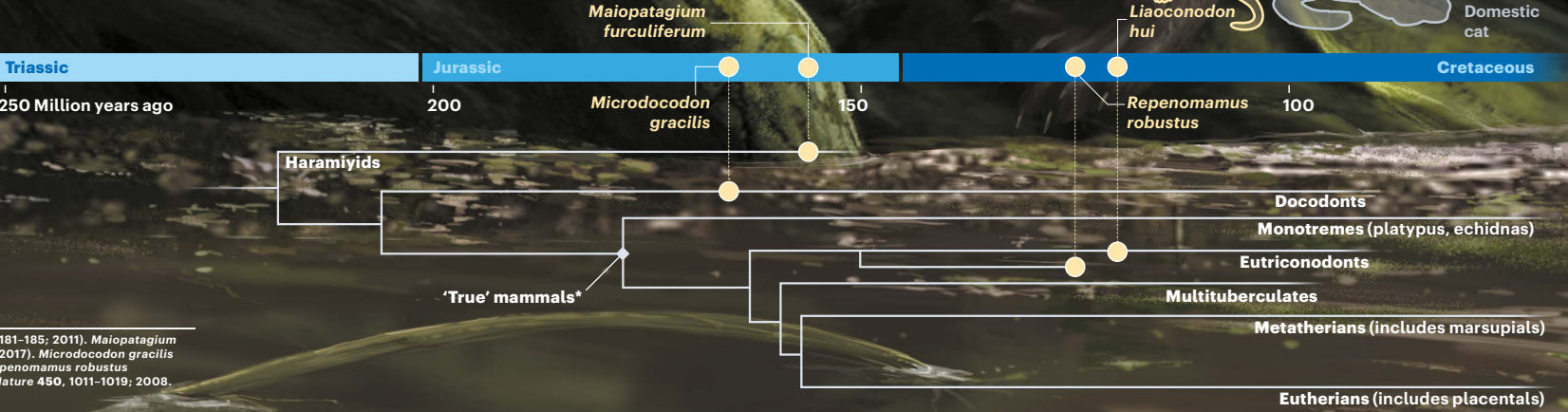
**GREAT AND SMALL**  
Early mammals came in a wide assortment of shapes and sizes, from the badger-sized *Repenomamus* (pictured right) and groundhog-like *Vintana*; to *Liaconodon* (main picture), about the size of a rat; and tiny vole-like *Microdocodon* (pictured right).

## DEBATABLE DYNASTY

Researchers disagree about the shape of the mammal family tree, which species fall in or out of it, and even where the tree begins. One view suggests that the earliest true mammals are 178 million years old; another argues that the oldest mammal dates from 208 million years ago. Many recent fossil finds represent long-extinct groups that branched off before the tree gave rise to the three groups of modern mammals.

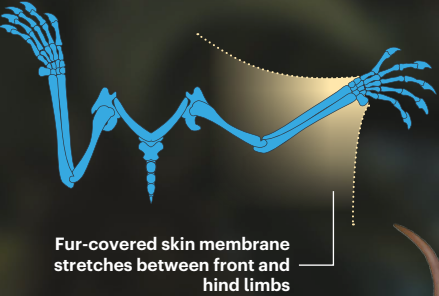
*Liaconodon hui* and evolution of the ear bones (J. Meng et al. *Nature* 472, 181–185; 2011). *Maiopatagium fursuliferum* and gliding mammals (Q.-J. Meng et al. *Nature* 548, 291–296; 2017). *Microdocodon gracilis* hyoid bone and suckling (C. F. Zhou et al. *Science* 365, 276–279; 2005). *Repenomamus robustus* (Y. Hu et al. *Nature* 433, 149–152; 2005). Timeline adapted from Z.-X. Luo *Nature* 450, 1011–1019; 2008.

\*Researchers do not know the exact timing of when lineages split from each other



## GALLERY OF TALENTS

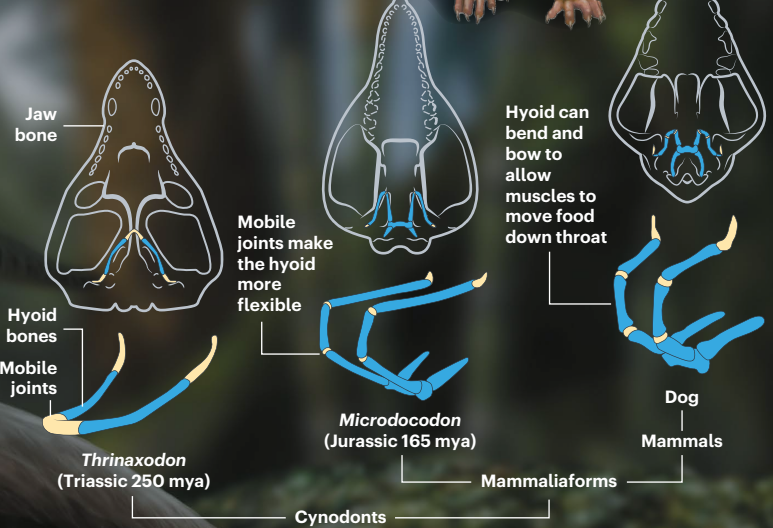
Many archetypal mammalian features evolved in a short burst early in mammal evolution, including innovations in movement, development and diet.



**SKY GLIDERS**  
Several modern mammals glide on wings of stretched skin, but the exquisitely preserved furry membranes of Jurassic-era *Maiopatagium fursuliferum* revealed that this ability evolved early, by 160 million years ago. Squirrel-sized *Maiopatagium* probably feasted on fruit, but other gliders from the same period had teeth more suited to seeds.

## SUCKLING AND SWALLOWING

All mammals nourish their young with milk, and to do this, the juveniles require a special bone in their throats to suckle and swallow. *Microdocodon gracilis* from the Jurassic has a form of this hyoid bone that resembles that of modern mammals and is the earliest mammal known to have suckled milk.



**DINOSAUR DINNER**  
Species like *Repenomamus robustus* from the Early Cretaceous challenge the typical stereotype of early mammals as diminutive insect-eating fluffballs. This creature was the size of a badger and a specimen found in 2005 had the bones of a baby dinosaur – a beaked, bipedal *Psittacosaurus* – in its stomach.